INSTITUUT VOOR KERN- EN STRALINGSFYSICA

WITCH:

Status & Future

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Outline

- What physics are we looking for?
  + How do we measure it?
- Principles of WITCH
- Status
- Future
- Conclusion

Weak Interaction Physics

$$H_{\text{int}} = (\bar{\psi}_p \psi_n)(C_S \bar{\psi}_e \psi_\nu + C'_S \bar{\psi}_e \gamma_5 \psi_\nu)$$ Scalar

$$+(\bar{\psi}_p \gamma_\mu \psi_n)(C_V \bar{\psi}_e \gamma_\mu \psi_\nu + C'_V \bar{\psi}_e \gamma_\mu \gamma_5 \psi_\nu)$$ Vector

$$+\tfrac{1}{2}(\bar{\psi}_p \sigma_{\lambda_\mu} \psi_n)(C_T \bar{\psi}_e \sigma_{\lambda_\mu} \psi_\nu + C'_T \bar{\psi}_e \sigma_{\lambda_\mu} \gamma_5 \psi_\nu)$$ Tensor

$$-(\bar{\psi}_p \gamma_\mu \gamma_5 \psi_n)(C_A \bar{\psi}_e \gamma_\mu \gamma_5 \psi_\nu + C'_A \bar{\psi}_e \gamma_\mu \psi_\nu)$$ Axial Vector

$$+(\bar{\psi}_p \gamma_5 \psi_n)(C_P \bar{\psi}_e \gamma_5 \psi_\nu + C'_P \bar{\psi}_e \psi_\nu) + h.c.$$ Pseudoscalar

Standard Model (V-A Int.): $C_S = C_S' = C_T = C_T' = 0$

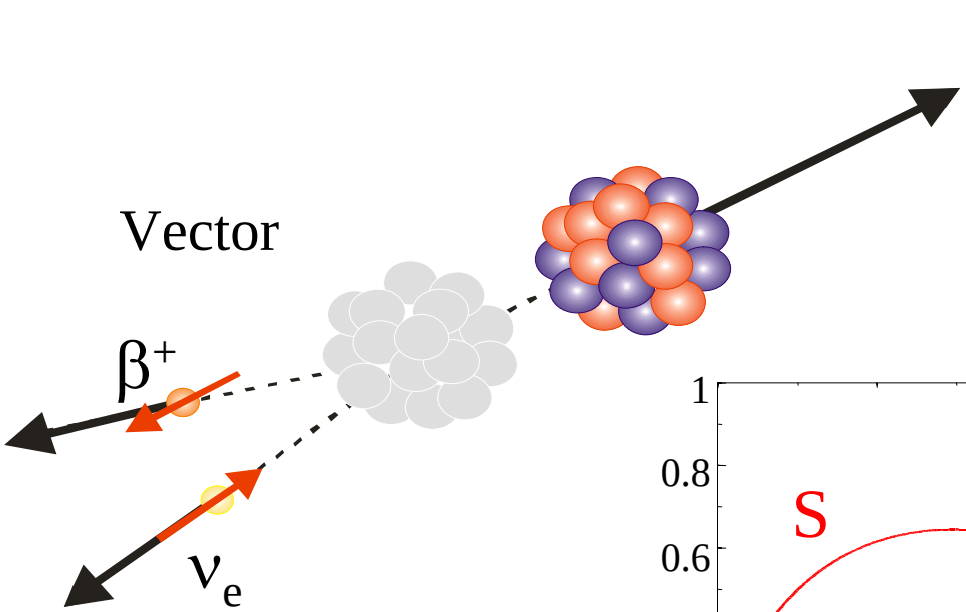
$$\left|\frac{C_T}{C_A}\right| \leq 9\% \qquad \left|\frac{C_S}{C_V}\right| \leq 7\%$$

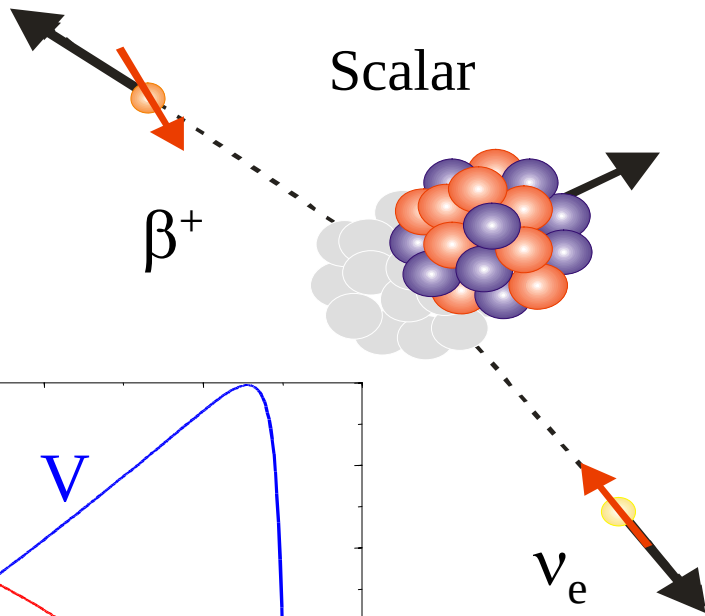
95.5% CL (2σ)

Physics Principle

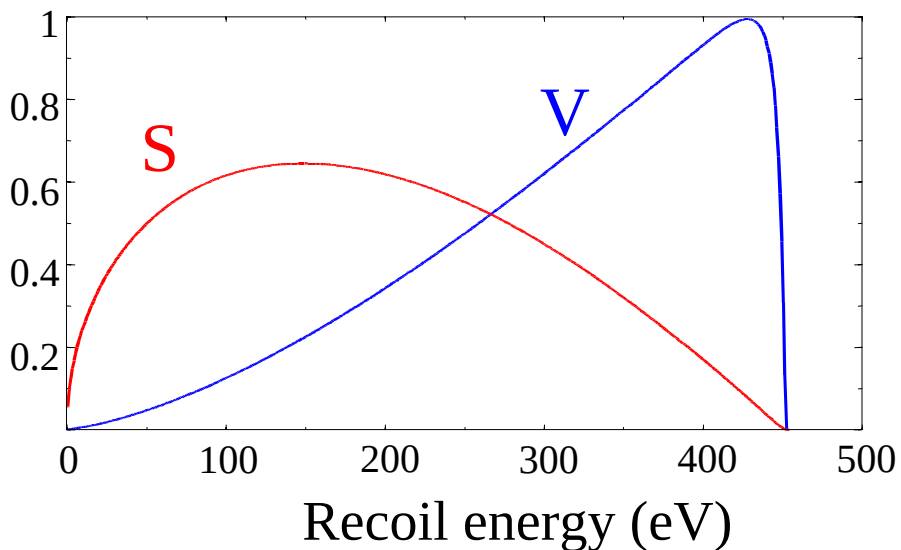
β-ν correlation

$$W(\theta) \cong 1 + a\frac{v}{c}\cos(\theta) \qquad a \approx 1 - \frac{|C_S|^2 + |C_S'|^2}{|C_V|^2}$$



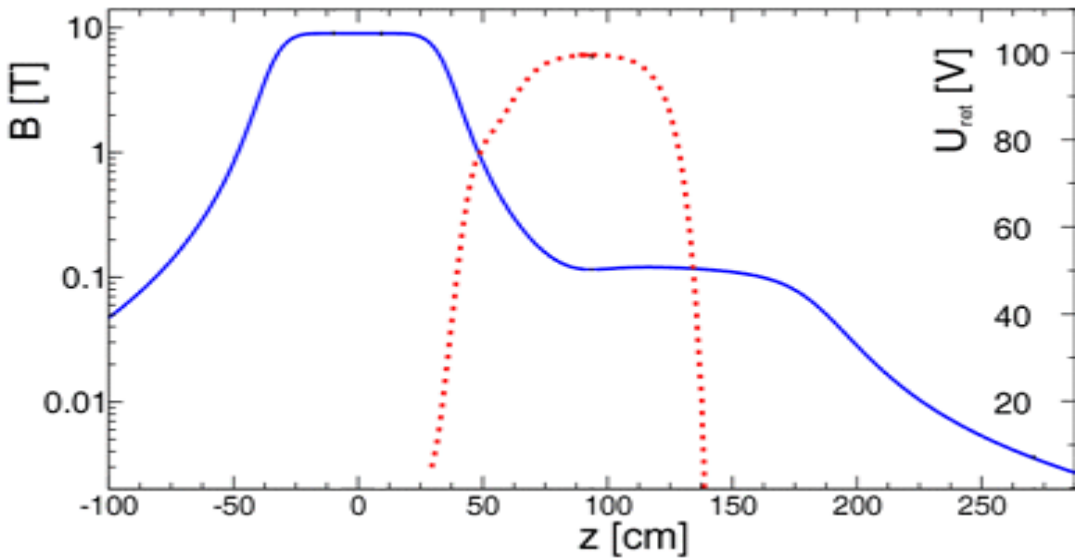


e.g. Fermi β⁺-decay



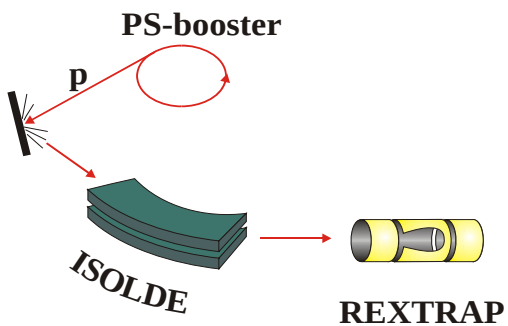
WITCH setup

WITCH = Weak Interaction Trap for CHarged particles

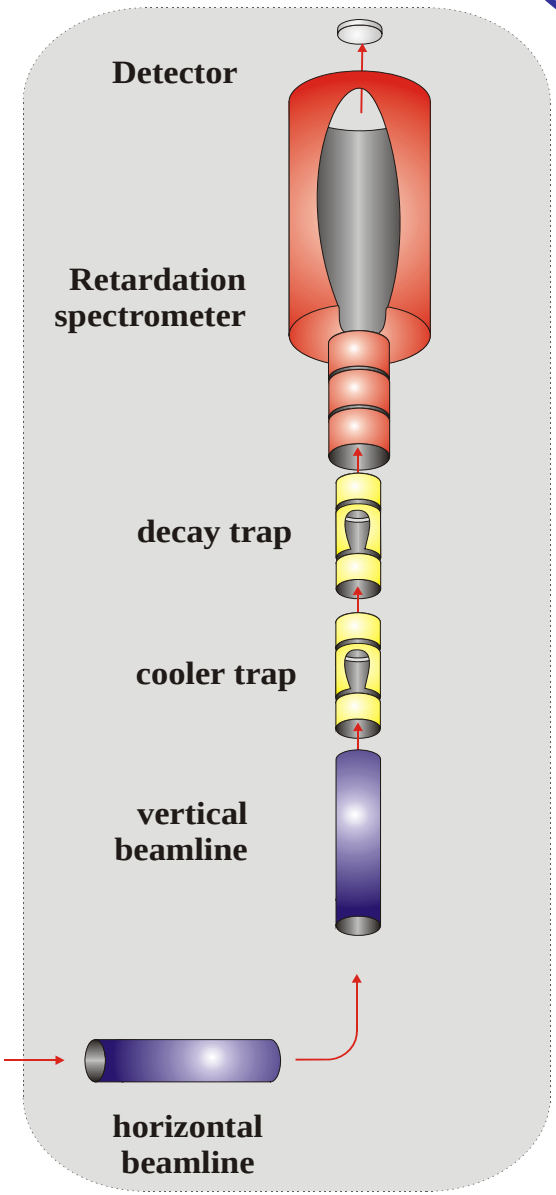


Magnetic field

Electrical field (retardation voltage)

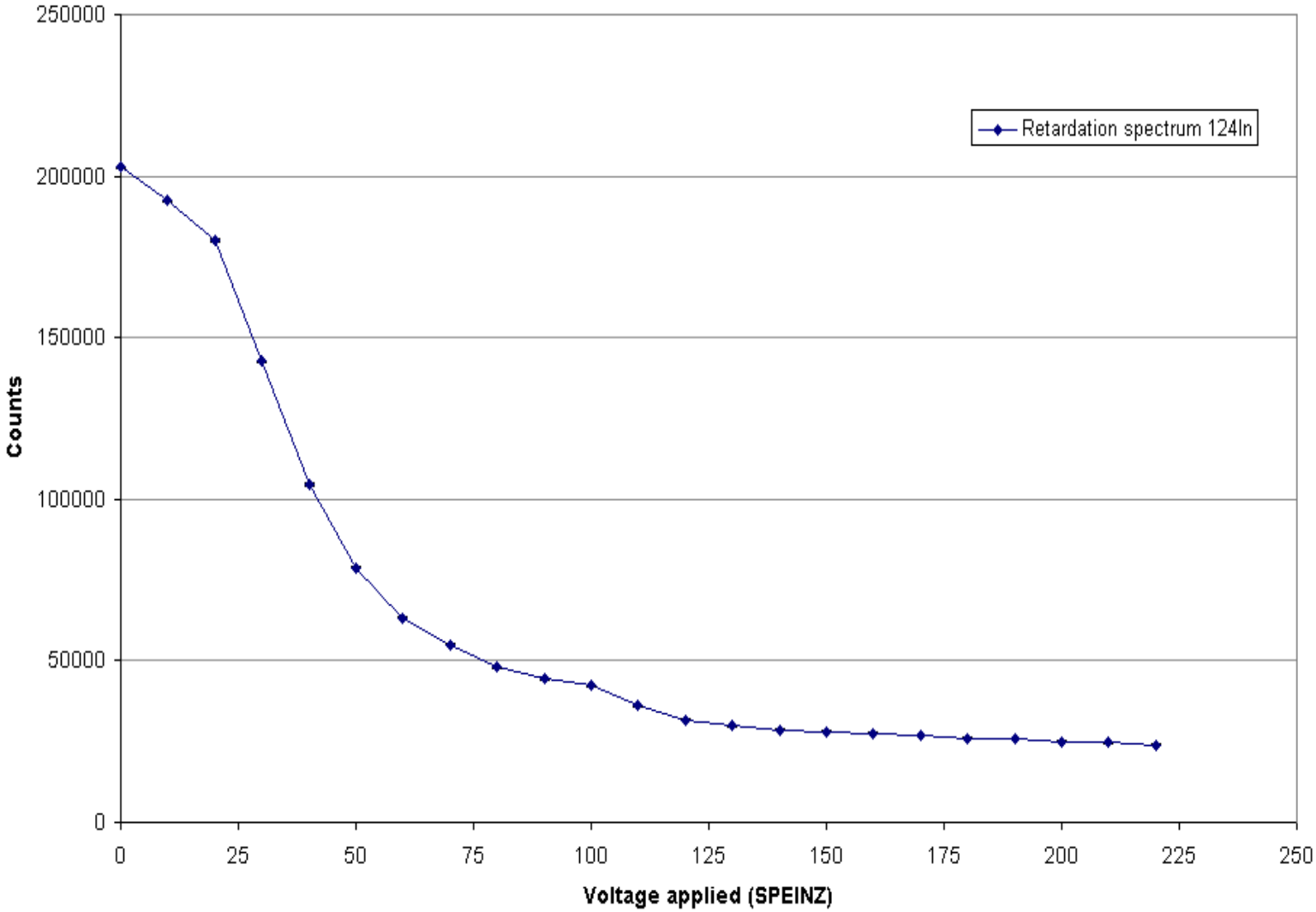


REXTRAP



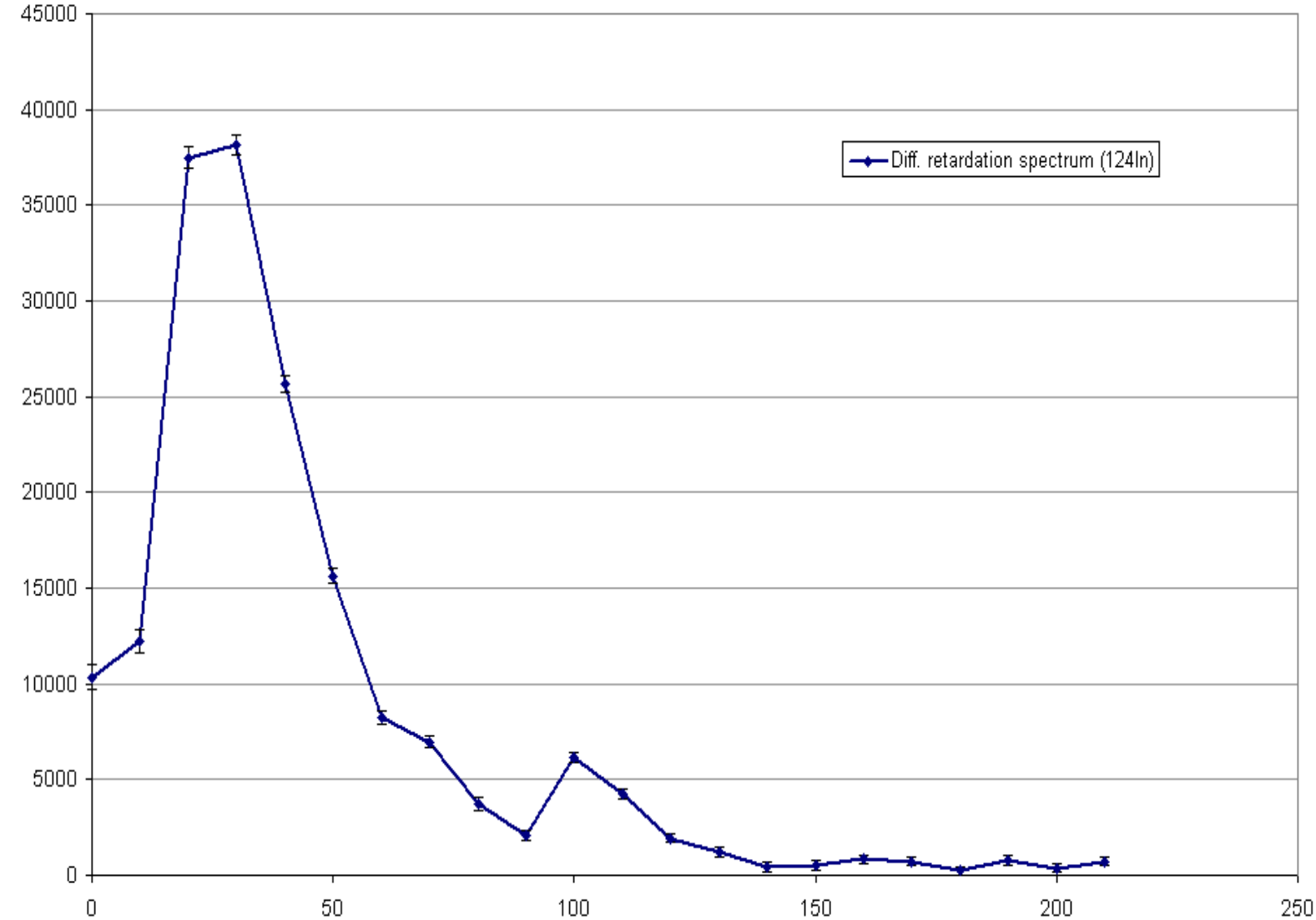
Recoil measurements: int. spectrum

WITCH-experiment 03 nov 2006



Recoil measurements: diff. spectrum

WITCH-experiment 03 nov 2006



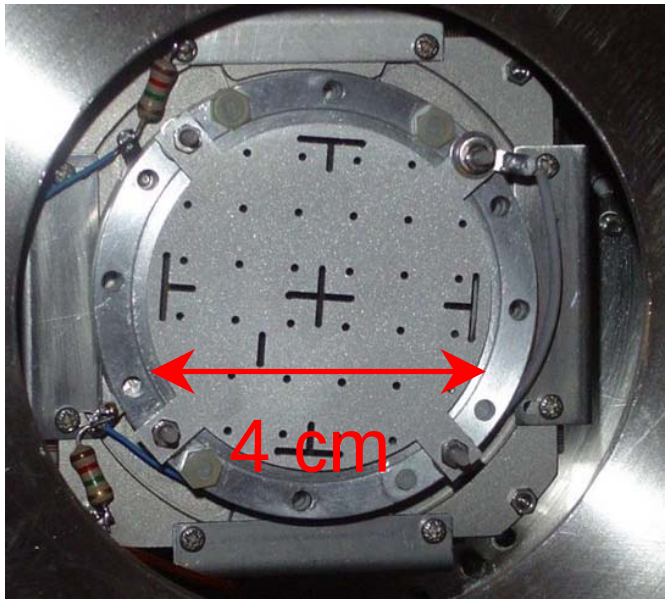
Offline tests

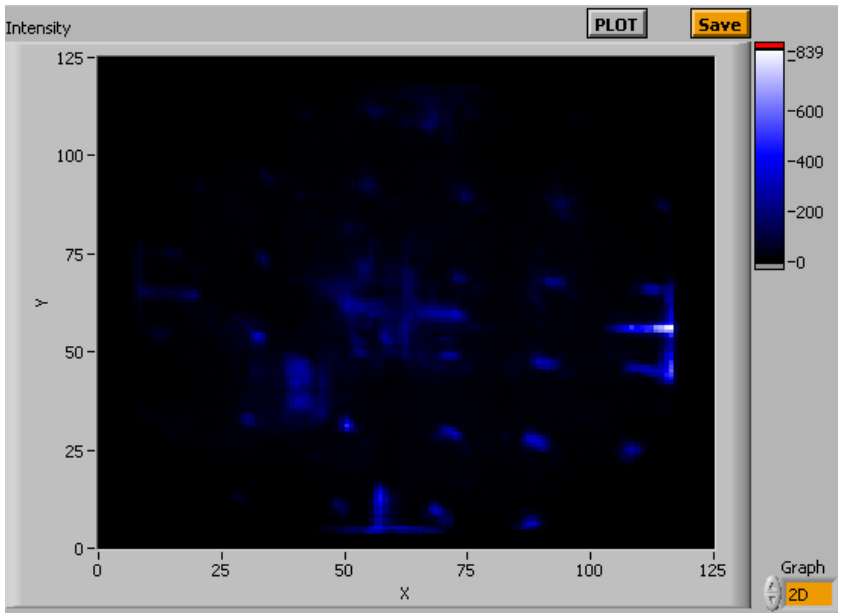
- December 2006: offline tests
- Separate β-background from γ-background
- β-source: ^{90}Sr β's Q-value: 546 keV
  ^{90}Y β's Q-value: 2280.1 keV
- γ-source: ^{60}Co γ's most important branch: 1173, 1332 keV
- Both tests show a constant background
  -> background is not energy dependent
- Switching the spectrometer in big steps (>20V) in combination with a γ-source gives rise to an enormous amount of ionisation -> to be investigated and/or avoided

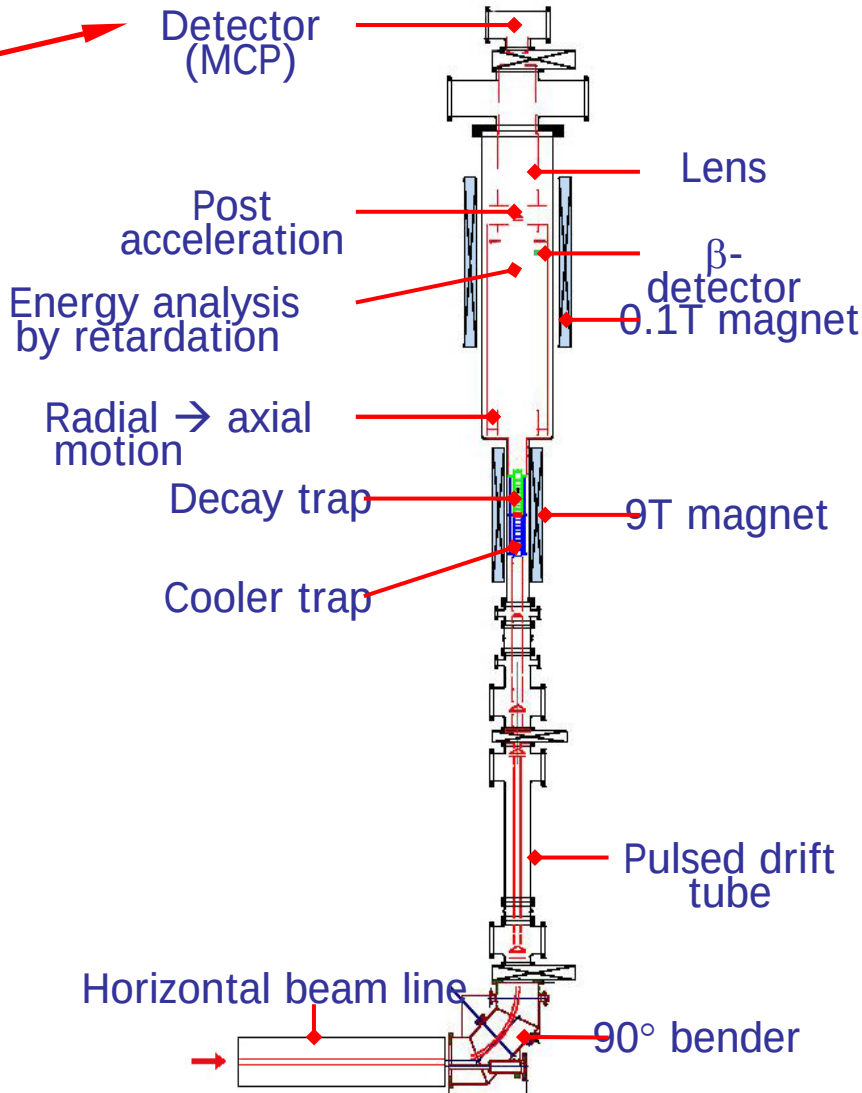
Efficiencies

Section	Efficiency
Transport through horizontal beam line and pulse down (30 keV → 0.2 keV)	~ 80 %
Injection of 0.2 kV beam in 9 T magnetic field	~ 20 %
Trapping of ions in cooler Penning trap	~ 60 %
Transfer to and storage in decay trap	~ 80 %
Shake-off + fraction leaving the trap	~ 30 %
Transmission of retardation spectrometer MCP efficiency	~ 50 % ~ 50 %
Total efficiency (REXTRAP to recoil ion MCP detector)	**~ 0.6 %** (ideal: ≈ 12 %)

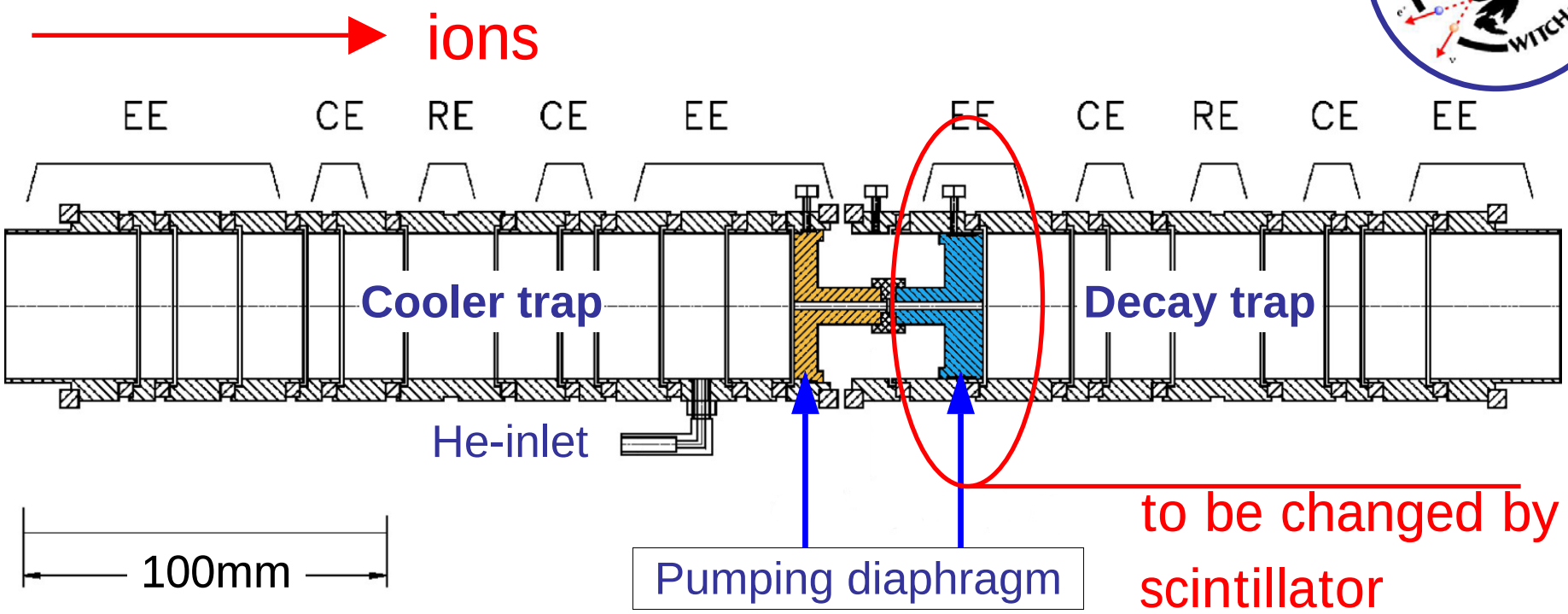
Main MCP + Position Sensitivity





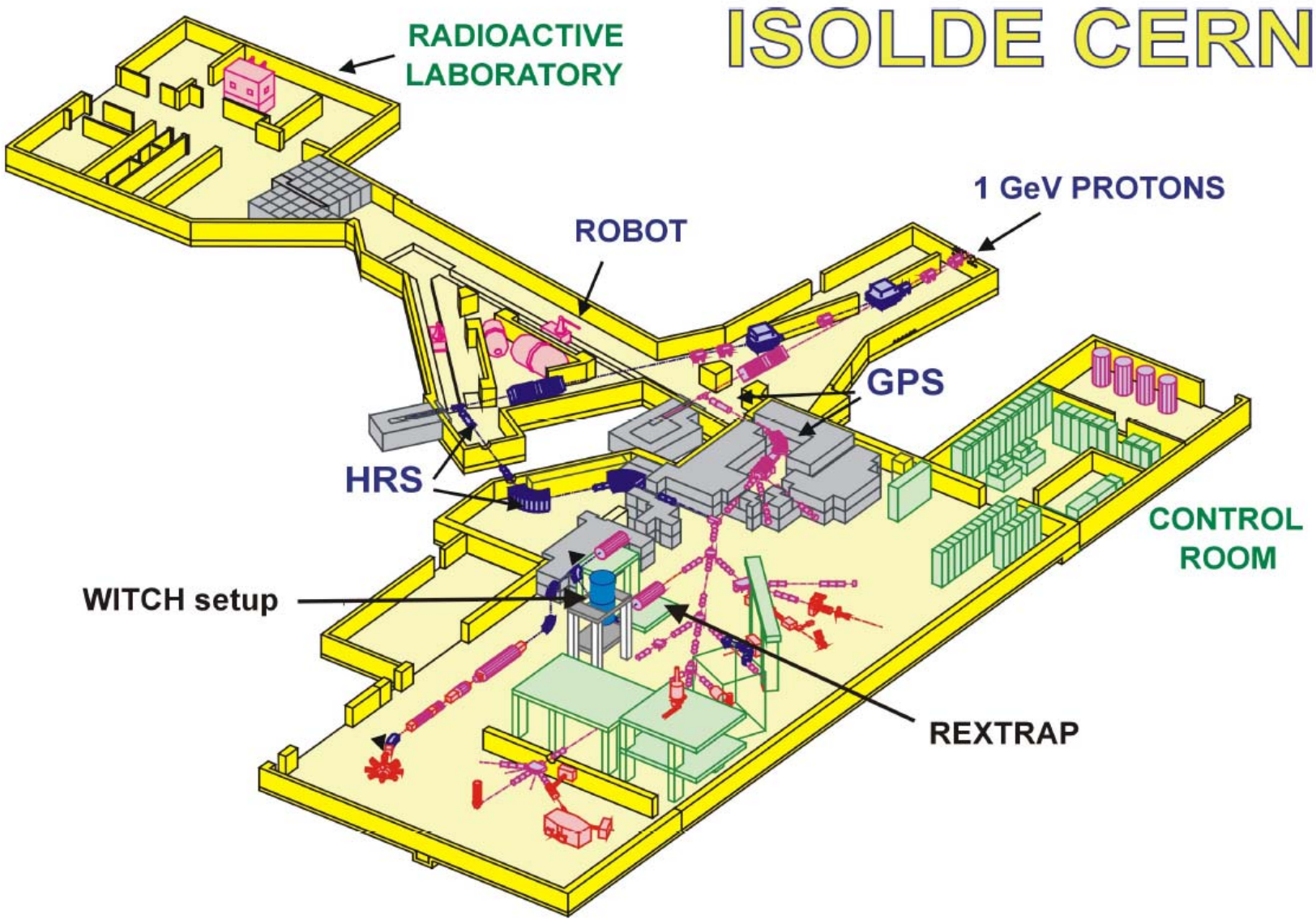


Future: In-trap β-detector



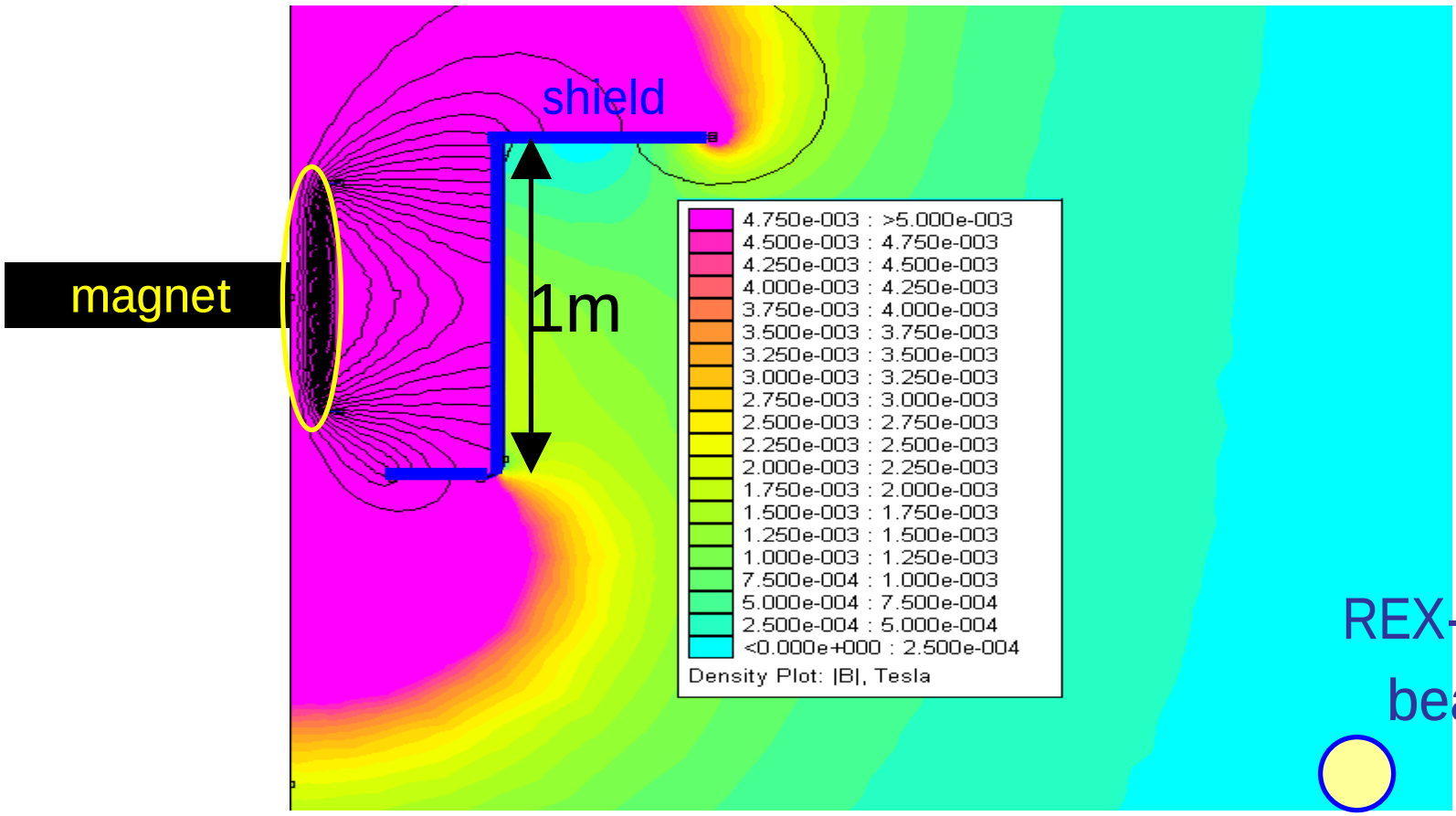
- To have normalization between different trap loads
- To evaluate β-background on main detector online
- To have a start signal for a TOF measurement
- ...?

Future: Antimagnetic Screen

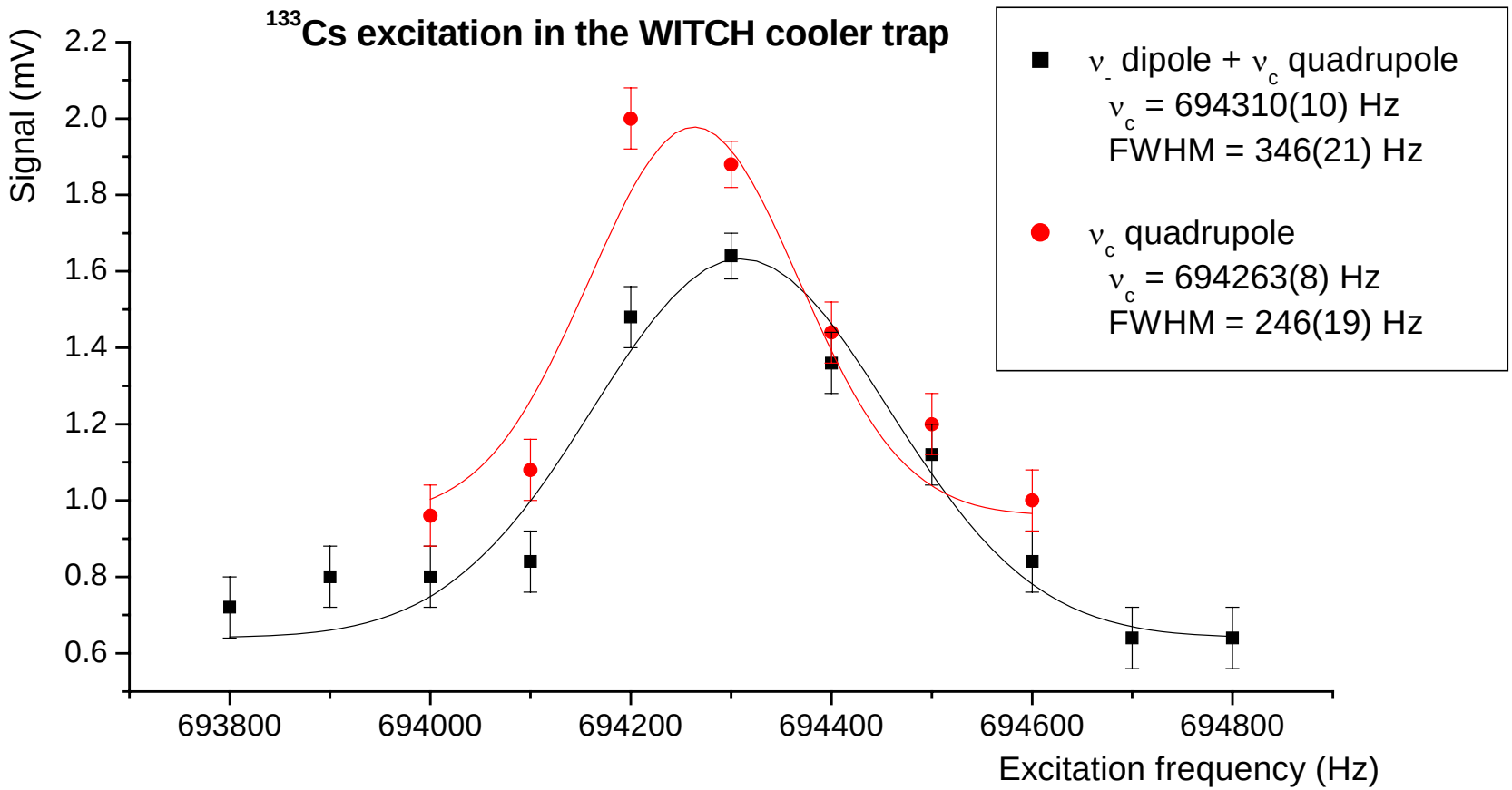


Future: Antimagnetic Screen

- The REX-ISOLDE experiment will be upgraded to reach higher energies
- Our magnet (9 and 0.2T) interferes with the beamline



Future: Trap tests



- Octupole Excitation: narrower FWHM
- SWIFT Excitation: Mass-selective expulsion from trap

More physics + Distant future (2-3y)

- Tensor interactions
- F/GT mixing ratio
- EC/b^+ ratio
- Charge state distribution
- Search for heavy neutrinos
  (kinks in the recoil spectrum)
- Half life studies (using the traps to purify the beam)
- ... ?

- Cooling the cooler trap (with LN_2) for a better response function
- Beta detectors around decay trap
- NEG (Non Evaporative Getter) strips

Conclusions

- Measuring a recoil ion spectrum works!
  And a lot has been realised in the past year

- Many optimalizations and additions are possible to obtain the precision experiment we're looking for